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Tools and Technology Article

Traditional and New Cable Restraint Systems to Capture Fox in Central Spain

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ABSTRACT Capturing animals is an essential tool of wildlife management, but the use of capture devices is being affected by public pressures on an international scale. In Europe, and particularly Spain, foxes (*Vulpes vulpes*) are often captured using traditional methods such as nonlocking Spanish Snares (SS) set in an ad hoc fence line known as an alar, but these traditional European methods are rarely compared to modernly described restraints such as the Wisconsin Cable Restraint (WR). We evaluated rates of efficiency, selectivity, injury, and impacts to foxes and nontarget species when using SS (as traditionally set in an alar) or WR within alars or on trails in Castilla-La Mancha, Spain. During 40,372 trap-nights from summer to winter of 2007, we captured 64 foxes, and 8 of 23 potential nontarget species. Our results indicated that WR set in trails were more efficient (0.28 capture rate) for capturing red foxes than SS set in an alar (0.11 capture rate). Relative to injury, foxes captured with the WR in the alar (95.4%), and WR in trails (90.5%), and the SS (90.9%) showed no indicators of poor welfare, and injury score analysis indicated that injuries were of similar magnitude for all capture devices. Overall, the WR set in trails may have performed the best, but all 3 methods are likely sufficient for capturing foxes with minimal injury, acceptable efficiency, and acceptable impact to foxes and sympatric nontarget species. Thus, wildlife managers in Spain and elsewhere can apply our findings to optimize capture and management of foxes.

KEY WORDS alar, cable restraint, fox, nontarget, snare, trap, *Vulpes vulpes*.

In most European countries, terrestrial carnivores are trapped to decrease the impact of predation on other valuable species, especially game and livestock (Harris et al. 2006). European laws, however, require competent authorities to limit authorized techniques to selective trapping methods (Council of Europe 1979, Council of the European Communities 1991, Consejo de las Comunidades Europeas 1992). Additionally, international agreements regarding trapping have been created (European Union–Canada–Russian Federation 1998, United States of America–European Community 1998). The agreements require examination of traps relative to animal-welfare standards with the goal of limiting injuries to captured animals (International Organization for Standardization [ISO] 1999). The reliance on capture techniques for management, combined with public interest in improving methods, means that scientific evaluation is needed to determine if devices meet accepted standards (Harris et al. 2006).

In Europe, the red fox (*Vulpes vulpes*) is the species most often live-trapped because it most often comes into conflict with humans (Ruette et al. 2003, Sillero-Zubiri et al. 2004). Snares and cage-traps are usually authorized for fox capture (Federation of Fieldsports Associations of the European Union 1998). In spite of the widespread use of snares, there is a limited amount of scientific data about their effects on the welfare of target species or additional impacts on nontarget species (Shivik and Gruver 2002, Independent Working Group on Snares 2005); most published information is from captures for radiotagging studies and is not specifically for testing capture devices (Frey et al. 2007).

In Spain, previous studies have evaluated several types of capture methods (Duarte and Vargas 2001; Ferreras et al. 2003, 2007; Herranz et al. 2007). One study examined the selectivity of neck-snares as set according to traditional procedures (Herranz 1999). The methods in these previous studies were not always thoroughly evaluated according to accepted international procedures as with other traps and species (Phillips et al. 1996; Shivik et al. 2000, 2005; Muñoz-Igualada et al. 2008). It is thought that devices such as cage-traps generally have very low selectivity, and snares are associated with a high mortality rate when foxes become entangled on or in fences or shrubs (Herranz 1999, Muñoz-Igualada et al. 2008).

Our objective was to provide scientific information about the use of old and modern capture devices for Spain (and presumably elsewhere in the European Union and the world). Specifically, we evaluated traditional and recently developed capture methods from Spain and the United States.

STUDY AREA

We conducted trials in the province of Ciudad-Real, Autonomous Community of Castilla-La Mancha, Spain.

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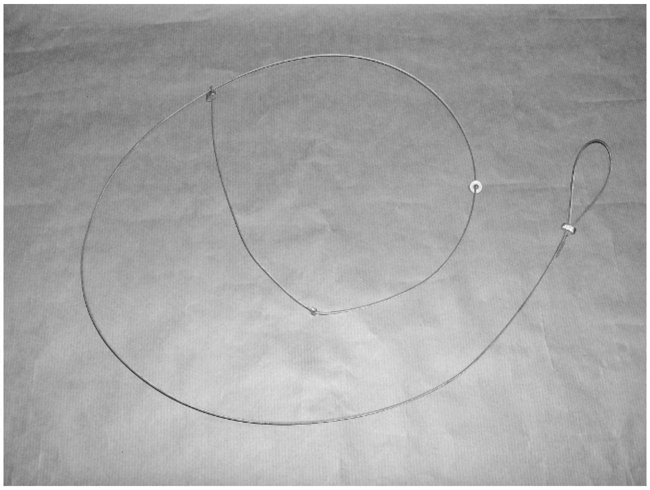

Figure 1. The Spanish Snare used in a study of injury, efficiency, and selectivity of cable restraints for foxes where devices were set from June to December 2007, in Castilla-La Mancha, Spain.

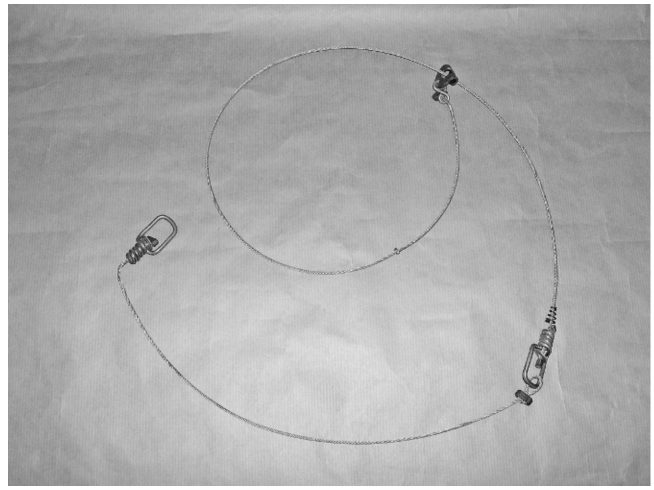

Figure 2. The Wisconsin Restraint used in a study of injury, efficiency, and selectivity of cable restraints for foxes where devices were set from June to December 2007, in Castilla-La Mancha, Spain.

The study site covered an area of approximately 700 ha between 2 adjacent estates: Peñas Negrillas (public) and La Mina (private). The climate was continental Mediterranean with a high of 41° C in summer and low of −3° C in winter. Vegetation was sclerophyllous evergreen holm–cork and oak forest. The current vegetation, however, was a typical Iberian Mediterranean mosaic of open holm–cork and oak woodlands, shrublands, xerophytic grasslands, and crops. Soils were acidic and nutrient-poor, derived from slate or quartzite parent rock materials. The estates were extensively managed for multiple purposes, mainly big and small game, livestock, and agriculture. More detailed information on topographical and ecological features can be found in Allué-Andrade (1990) and Rivas-Martínez et al. (2002).

METHODS

From June to December 2007, we assessed the presence of terrestrial carnivores, including foxes, which potentially could have been captured at the site using 6 remote, automatically triggered cameras (Model DC-2BU, Leaf River, Taylorsville, MS). We selected camera locations by first choosing active trails (i.e., trails that contained tracks and spoor), then baiting each active trail with trapping bait (Collarum Bait, Wildlife Control Supplies, East Granby, CT) to mimic site attraction as if we were using baited traps. The cameras monitored locations 24 hours per day and used an automatically triggered flash at night. We also recorded species present by logging observations of animals and sign (i.e., tracks, feces) and by reviewing previous work in the same area (Alda et al. 2008; A. Aranda, Fundación CBD-Hábitat, Junta de Comunidades de Castilla-La Mancha, unpublished data).

After using cameras to determine which species were present in our study area, we began trapping. We used 2 different nonpowered cable restraint devices: the Spanish Snare (SS) and the Wisconsin Restraint (WR). The SS is authorized for use in Spain, is commonly used, and is made by local blacksmiths from 1.65-m multi-strand steel cables (1.75-mm diam) that end in a simple loop (rather than a lock). A stop made of a crimp knot in the wire (25 cm from the loop) and a washer put in-line prevents the snare from closing smaller than 8 cm in diameter (Fig. 1). The WR was initially tested in trials developed in Wisconsin (Association of Fish and Wildlife Agencies 2008) and is built with a 180°-bend relaxing-type lock on 1.52 m of 7 × 7 2.44-mm aircraft cable. It incorporates 2 swivels (end swivel and in-line swivel), a commercially manufactured breakaway S-hook (rated at 50 kg), and a stop that prevents the loop from closing to <6.54 cm in diameter (Fig. 2).

We used 2 methods for placing restraints. We based the first method on a traditional Spanish approach locally called an alar. We made the alar by first constructing a 1,000-m linear pile of brush and branches (0.5 m wide × 0.5 m high) using materials at the site. We then opened 0.4-m gaps in the alar at 10-m intervals and set a restraint in each gap. We anchored SS to a branch within the alar and stabilized them using a rigid wood stick. We anchored WR into the ground with a stake and supported them using a stiff wire. We randomly assigned restraints to each gap (Fig. 3). The loop height above ground level was 20 cm for all restraints.

In the second restraint placement method, we set WR in fauna trails as prescribed in some parts of the United States; that is, we identified trails (especially fauna trails) in areas proximal to the alar within a buffer 1 km from the alar, and we placed restraints according to Association of Fish and Wildlife Agencies (2008) using wire supports and anchored them with stakes. We set restraints far enough from fences or rooted woody vegetation to prevent entanglement (Fig. 4).

We checked all devices every morning. To minimize the number of animals sacrificed, we based end-points of capture efforts on the number of animals captured and not necessarily on trap-nights. We began field work on 14 June 2007, when 50 units of each restraint type were set. To increase sample sizes, we added 25 more units for each

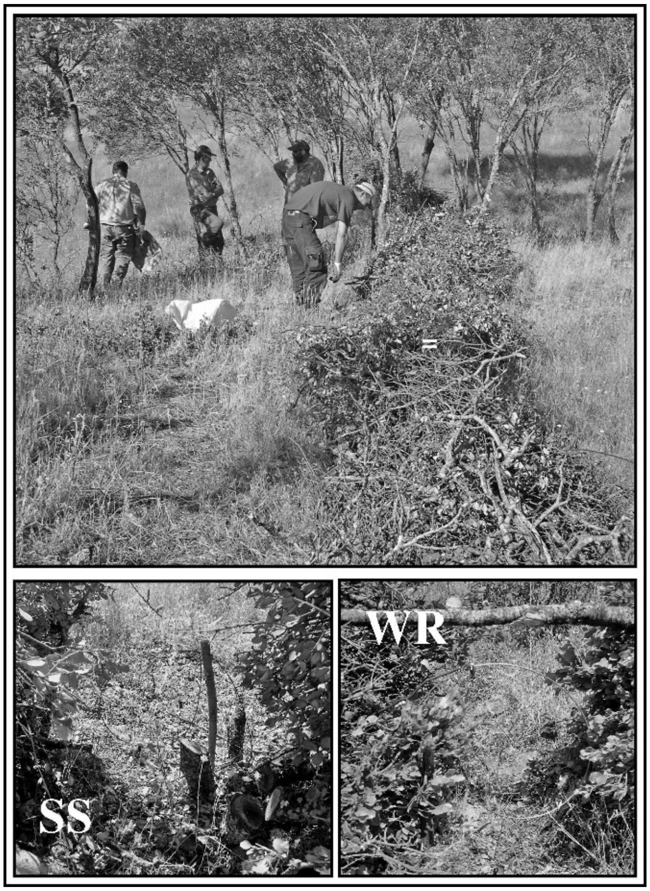

Figure 3. Spanish Snares (SS) and the Wisconsin Restraints (WR) set in the linear pile of brush and stacked branches (alar), during a study of injury, efficiency, and selectivity of cable restraints for foxes in Castilla-La Mancha, Spain, from June to December 2007.

method on 10 August (simultaneously lengthening the alar to 1,500 m) and continued with a capture effort of 75 restraints/day/method until 6 October 2007. We set all devices concurrently and with equal effort between 14 June and 6 October and, thus, only data from this period were used to compare efficiency and selectivity between devices.

On 6 October 2007 we removed all WR on trails because they captured the minimum number of foxes (20) needed for evaluation. We then tried to obtain minimum sample sizes of foxes captured with the other methods as quickly as possible by adding SS and WR devices. Specifically, we lengthened the alar from 1,500 m to 3,350 m, and we added 92 SS and 92 WR. On 20 October we captured the 20 foxes needed for evaluating WR in the alar, so we removed those restraints and replaced them with SS. On 30 November we captured the required 20 foxes in SS, and on 2 December we terminated capture operations and removed all restraints.

We euthanized captured foxes with a captive bolt to the head (American Veterinary Medical Association 2001). We immediately froze and shipped collected carcasses to the Veterinary Faculty of the University Complutense of Madrid, where whole-body necropsies were performed by a veterinary pathologist. The veterinarian necropsied animals by skinning and examining the entire body for injury; we summarized necropsy data and scored injuries in accordance with internationally accepted procedures (ISO 1999).

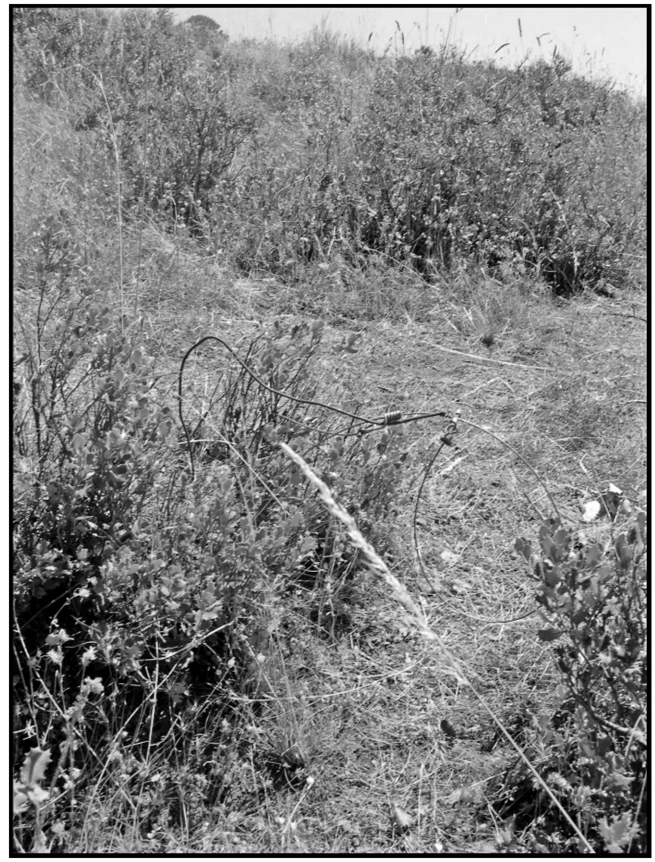

Figure 4. Wisconsin Restraint set in fauna trails, during a study of injury, efficiency, and selectivity of cable restraints for foxes in Castilla-La Mancha, Spain, from June to December 2007.

Finally, we assessed injuries using internationally agreed-upon indicators of poor welfare (European Union–Canada–Russian Federation 1998, United States of America–European Community 1998). That is, we regarded the following categories as indicators of poor welfare: self-directed biting leading to severe injury (self-mutilation), excessive immobility and unresponsiveness, fracture, joint luxation proximal to the carpus or tarsus, severance of a tendon or ligament, major periosteal abrasion, severe external hemorrhage or hemorrhage into an internal cavity, major skeletal muscle degeneration, limb ischemia, fracture of a permanent tooth exposing pulp cavity, ocular damage including corneal laceration, spinal cord injury, severe internal organ damage, myocardial degeneration, amputation, or death. A device showed evidence of exceeding the standards if $\geq 80\%$ of a sample of 20 captured animals exhibited none of these indicators.

We evaluated the impact of capture on nontarget captured animals first with a veterinary exam and then with remote monitoring. A field veterinarian anesthetized captured animals with a combination of Ketamine and Medetomidine and then examined them for trap-related injuries. Examinations included a fluoresceine test to check for potential injuries in the eyes (Scott 2003). Once examined, we reversed the drug effect using Atipamezol, and we released the animals in situ. When possible, we radiotagged captured nontarget animals with transmitters equipped with a mortality sensor (mammals: TW-3, 50 g, Biotrack, Wareham, Dorset, United Kingdom; raptors: PU, 15 g, Ayama, Barcelona, Spain). After capture, we checked activation of the mortality sensor until the study ended on 15 December.

We considered the individual restraint as the experimental unit for differences in efficiency and selectivity. We used binomial analyses, particularly logistic regression (function *GLM* with binomial family errors in R software; Crawley 2007). The binomial response variables were efficiency (coded as yes if an individual trap captured a fox and no if not) or selectivity (coded as yes if the individual trap captured a nontarget species and no if not). Restraint type was the predictor variable in both analyses with 3 levels: SS in alar, WR in alar, and WR on trails. We checked for the fit of the models by means of logistics plots and corrected overdispersion by using quasibinomial errors rather than binomial (Crawley 2007).

The captured animal was the experimental unit for the injury analysis using ISO injury score as the response variable. For analysis, we used a 2-factor analysis of variance to detect differences, and potential interaction, between the different types of restraints and the area of the body around which the animal was restrained: neck or body. Log-transformation was required to satisfy assumptions of normality (checked by means of probability plots) and variance homogeneity (checked by plots of studentized residuals against groups of means). We made multiple comparisons with Tukey's honestly significant difference tests (Quinn and Keough 2002).

RESULTS

Of the 58 photographs obtained, the red fox was the species most photo-captured ($n = 54$), with far fewer instances of European wild cat (*Felis silvestris*, $n = 2$), Eurasian badger (*Meles meles*, $n = 1$), and Egyptian mongoose (*Herpestes ichneumon*, $n = 1$). Other carnivores detected using sign or visual observations were stone marten (*Martes foina*), small-spotted genet (*Genetta genetta*), and domestic dog (*Canis lupus familiaris*). We did not detect Iberian lynx (*Lynx pardinus*) but other authors have concluded that it occurs, but is rare at the site (Alda et al. 2008). We also observed diurnal raptors (*Accipiter gentilis*, *Aquila adalberti*, *Buteo buteo*, *Hieraaetus fasciatus*, *Milvus migrans*, and *Falco tinnunculus*), nocturnal raptors (*Bubo bubo*, *Athene noctua*, *Strix aluco*, and *Tyto alba*), and corvids (*Corvus monedula*, *C. corax*, and *Pica pica*). The game species that we observed were red deer (*Cervus elaphus*), European boar (*Sus scrofa*), European rabbit (*Oryctolagus cuniculus*), and hares (*Lepus granatensis*).

From 14 June to 2 December 2007, we captured 64 foxes, 8 individuals of 4 nontarget species, and 14 individuals of 4 game species. Specifically, the WR on trails captured 1 Eurasian eagle owl, 2 European wildcats, 1 Egyptian mongoose, and 5 game animals (3 rabbits and 2 hares). The WR in the alar captured 2 Egyptian mongoose and 6 game animals (3 hares, 1 rabbit, 1 young wild boar, and 1 young red deer). The SS captured 2 domestic dogs and 3 game animals (2 hares and 1 young deer).

The SS in the alar restrained 15 foxes around the neck and 7 around the body; the WR in the alar restrained 14 foxes by the neck and 7 around the body; the WR on a trail restrained 13 foxes around the neck and 8 around the body.

While we compared efficiency and selectivity (14 Jun–6 Oct), which included 75 of each device tested, the WR on trails captured 21 foxes and 4 nontargets; the WR in the alar captured 16 foxes and 2 nontargets; the SS in the alar captured 8 foxes but no nontargets. With respect to efficiency, the rate of fox capture using WR on trails (0.28) was more than twice that for SS (0.11, $P = 0.009$). There was no evidence that rate of fox capture in WR on trails was significantly different than rate of fox capture in WR in the alar (0.21, $P = 0.345$). There was some evidence, however, that WR in the alar had a higher fox capture probability than the SS ($P = 0.079$). In terms of selectivity, significant differences between the different restraints were not apparent ($P > 0.414$). The relative capture rate for WR in trails was 0.05, WR in the alar was 0.03, and SS in the alar was zero, with no nontarget captures.

Most foxes captured with WR in the alar (95.4%, $n = 21$) and WR in trails (90.5%, $n = 21$) showed no indicators of poor welfare, although one fox captured with WR in the alar and 2 more with WR in trails suffered permanent tooth fracture exposing pulp cavity (Table 1). Finally, most foxes captured in SS did not show poor welfare indicators (90.9%, $n = 22$). The 2 foxes that showed these indicators had more severe injuries: both had internal bleeding in the abdominal region; one was held live in the alar, but the other pulled the wooden anchor away from the alar, became entangled in an adjacent shrub, and died.

When we examined foxes using the ISO injury scale, mean injury values caused by the SS, WR on trails, and WR in the alar were 21.8 (SE = 10.8), 10.3 (SE = 3.1), and 6.5 (SE = 2.4), respectively. The foxes restrained by the neck recorded a mean injury value of 13.1 (SE = 5.9), compared to 12.8 (SE = 2.9) computed for foxes captured around the waist. Overall, injuries were similar for all snaring methods ($F_{2,58} = 0.970$, $P = 0.385$) and capture-loop placement ($F_{1,58} = 2.989$, $P = 0.089$), without evidence of interaction between both factors ($F_{2,58} = 0.054$, $P = 0.948$).

On 8 occasions, we observed WR on trails release (using the installed breakaway device) wild boar or deer that had been captured; we recorded the same phenomenon 6 times with the WR in the alar. Two domestic dogs trapped with SS did not show visible injuries and were returned to their respective owners. The 2 Egyptian mongooses captured with WR in the alar did not show any moderate or severe traumas: one specimen was captured by the neck and the restraint caused it a mild cutaneous laceration, including cutaneous erosions in the mouth and on some digits; the other was captured by the abdominal region and suffered a mild edematous swelling at the groin and a mild cutaneous erosion at the ventral part of the muzzle. The European eagle owl captured in the trail-set WR also did not exhibit significant injuries, with only minor disturbances in some feathers and a light scratch in the right

Table 1. Observed injuries to foxes captured in different cable restraints and set types in Castilla-La Mancha, Spain, from June to December 2007. Data are from whole-body necropsies of foxes captured with trapping methods. Data reported are only for injuries that we observed and are not a complete list of all injuries that we examined carcasses for as listed in International Organization for Standardization (1999).

Pathological observations	SSA (n = 22)[a]		WRA (n = 21)[a]		WRT (n = 21)[a]	
	n	%	n	%	n	%
No injuries	9	40.9	12	57.1	8	38.1
Claw loss	0	0	1	4.8	1	4.8
Oedematous swelling or hemorrhage	1	4.5	0	0	4	19.0
Minor cutaneous laceration	3	13.6	7	31.8	5	23.8
Minor subcutaneous soft tissue maceration or erosion (contusion)	10	45.5	6	27.3	6	28.6
Major cutaneous laceration, except on foot pads or tongue	1	4.5	1	4.5	2	9.5
Fracture of a permanent tooth exposing pulp cavity	0	0	1	4.5	2	66.7
Major subcutaneous soft tissue maceration or erosion	1	4.5	0	0	1	33.3
Joint luxation at or below the carpus or tarsus	1	4.5	0	0	0	0
Severe internal organ damage (internal bleeding)	2	9.1	0	0	0	0
Death	1	4.5	0	0	0	0

[a] SSA = Spanish Snare set in an alar; WRA = Wisconsin Restraint in the alar; WRT = Wisconsin Restraint in fauna trails.

eye revealed by the fluoresceine test. We radiotagged and monitored the owl, and it remained in the study area after release, as indicated by radio and direct observations during the 9 subsequent weeks of monitoring. The first European wildcat captured in the trail-set WR showed mild laceration in the abdominal region, where the cable closed, and the fluoresceine test revealed a mild scratch in the left eye. Radiotracking showed that the wildcat remained in and traveled to different locations within the study area during the following 5 weeks. The wildcat was captured for the last time 38 days later at a nearby estate in a cage-trap; the veterinarian examined it again, and recorded a complete recovery from the injuries suffered from the previous capture. The second European wildcat captured in a WR in a trail showed mild lacerations at the abdominal area and light scratches in both eyes with the fluoresceine test. Finally the Eurasian mongoose captured in WR in a trail exhibited irritation of the corner of the mouth, contusions in the pectoral region, and mild cutaneous erosion at the abdominal area where the cable closed.

DISCUSSION

We successfully accomplished the objectives of our research by evaluating the relative effectiveness of older and more modern methods for capturing foxes, and of all metrics measured, efficiency was probably the most important. More specifically, our results indicated that restraints set on fauna trails were more efficient for capturing red foxes than the SS set in the alar, and the WR in the alar was intermediate in performance. We did not test the traditional SS in fauna trails because it had already been the object of a previous study that resulted in a high mortality rate due to entanglement, indicating that this method would not meet the current humane trapping standards and did not justify an additional sacrifice of animals (Herranz 1999).

As suggested in other studies (Independent Working Group on Snares 2005), how a device is set also influences efficiency. We set restraints systematically in the alar, but in fauna trails we set restraints in locations with clear and recent fox sign (tracks, fresh feces, etc.); it is possible that the alar, being a large, human-constructed element, could cause foxes to be more wary and, thus, be more likely to detect and avoid restraints. Restraints set on trails, on the contrary, may more easily blend in with elements of the surrounding vegetation and, thus, be more efficient for capturing foxes (Olson and Tischaefer 2004, Independent Working Group on Snares 2005). We initially supposed that an alar may act as a drift fence and actually funnel more foxes into sets, but the data suggest otherwise.

Overall, our fox capture rates were similar in magnitude to previous surveys developed in the United Kingdom and Spain (Herranz 1999, Independent Working Group on Snares 2005). The presence of many other species was consistent with the Atlas of Terrestrial Mammals of Spain (Palomo et al. 2007). Our detection of other species was not necessarily indicative of relative abundances, but at least for the SS in the alar (which had no captures of wild species) it appears that both the device and setting conditions are important aspects of the trapping system that influence nontarget and fox capture rates.

It seems feasible that the device and setting conditions could influence the behavior of different species of animals as they encounter a snare. Morphological differences (e.g., size, length, and thickness of the body) could also play an important role. Our setting methods (e.g., ht and size of loop) may reduce captures of genet and stone marten; have an intermediate impact on captures of wildcats, mongooses, and badgers; and increase captures of foxes or dogs. Overall 65% of foxes captured were restrained by the neck; however, the 2 wildcats captured were restrained by the waist. Variation in how cable restraints restrained animals could be explained by both morphology and how animals move through their environments: foxes and dogs may lead with their head while wildcats cautiously introduce the forelimbs first, which could explain why canids were restrained around the neck and felids around the body.

Captures of game species using the SS or WR were low due to installed breakaway devices and could also be a function of the alar itself, which, using a horizontal branch over the snare, forces larger species to jump over it, rather than crouch and go through the hole with the snare (Michigan Department of Natural Resources 2007). In fact, the captured big-game individuals (a deer with the SS and a wild boar with the WR in the alar) were young individuals that were restrained by the neck.

Injury data are categorical and the relative degree of pain experienced by an animal is difficult to transform into quantitative variables, and systems that subjectively assign scores to injuries have been noted to be inappropriate for statistical analysis (Engeman et al. 1997), but because injury scores are ubiquitous in the literature (Onderka et al. 1990, Phillips et al. 1996, Hubert et al. 1997) we still scored injuries. The restraints we tested, which are intended to restrain the animal around the neck or body, scored between 6.5 and 21.8 on the ISO scale, and potentially may cause lower injuries than methods that restrain limbs. For example Phillips et al. (1996) reported scores for traps from 29 to 103, and Onderka et al. (1990) reported scores for traps and cable foot-restraints to range from 21.6 to 64.9. More recent studies indicated that cable-type restraints scored from 21.5 to 50.4 (Darrow et al. 2009).

In our study, the most important injuries from the WR involved fractured teeth, which probably resulted from animals chewing on the cable or other hard elements around it. Injury scores between SS and WR sets were not significantly different, but data do suggest that the smaller cable may be more likely to cause tissue lacerations than larger cables (Table 1); >17% more foxes exhibited this injury in the SS, relative to the WR. Perhaps a coated cable, or a chew-tab that would encourage noninjurious displacement behavior could be attached to the cable and prevent tooth injury (Shivik et al. 2000). Although Spanish Snares had acceptable injury levels, the 2 foxes showing poor welfare indicators suffered more severe injuries than their equivalents for the WR. Perhaps the addition of swivels and earth-anchoring devices could make SS more useful for capturing foxes (in terms of minimizing injury and nontarget species captures). Our results support previous assertions that well-designed, stopped cable restraints can be a useful method to capture foxes without exerting severe injuries (Broom 2000, Frey et al. 2007) although in some circumstances snares can cause severe injuries, even leading to the death of the animals (Independent Working Group on Snares 2005, Harris et al. 2006).

Lastly, it is important to highlight that inferences from our results should only be extended to similar areas, habitats, and species assemblages. The physical aspects of capture devices are important to consider too; WR are referred to as snares, although snare is a more broad term that may include killing devices and spring-type cinching mechanisms that will affect performance.

MANAGEMENT IMPLICATIONS

Certain cable restrain designs can be used such that foxes can be captured with low injury rates and adequate efficiency while simultaneously minimizing impacts to many sympatric nontarget species in Spain. Restraint setting procedure can impact efficiency and welfare; however, so to ensure best practices additional research may need to be complemented with adequate regulations and training programs for trappers. Clearly, the height of the snare, size of the loop, and site characteristics influence how an animal is restrained; thus, research investigating animal behavior at restraint locations could prove beneficial for improving capture methods. Future testing ought to be considered, especially in regard to capture selectivity relative to Iberian lynx, before large-scale recommendations can be made in areas containing sensitive species.

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